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Piston-Type Accumulator

The invention relates to piston-type accumulators such as are provided, among other things, in conjunction with hydraulic assemblies for the purpose of holding specific volumes of a pressurized fluid (such as a hydraulic medium) to this assembly when required. Hydropneumatic (gas-impinged) accumulators are used nowadays in most hydraulic assemblies, the movable separating element inside the accumulator housing separating a fluid space as one operating space from a gas storage space as the other operating space. Nitrogen gas is regularly employed as operating gas, while the piston forming the gas-tight separating element to a great extent allows separation of gas supply space from fluid space.

The fluid component communicates with the hydraulic circulation of the assembly so that the accumulator receives fluid as the pressure rises and the gas is compressed. When the pressure drops, the compressed gas expands and forces the pressurized fluid stored back into the hydraulic circulation. The changes in the volume of gas supply space and liquid supply space result in a appropriate axial movement of the piston inside the accumulator housing.

A prerequisite for flawless behavior of piston-type accumulators is that the gas charging pressure prevailing in the gas supply space has a value adapted to the level of pressure of the fluid component, so that the piston is in a suitable position inside the cylinder housing so that the piston may execute the operating movements required in the axial direction between the end positions in the accumulator housing.

In view of the foregoing the object of the invention is to create a piston-type accumulator which makes it possible to fix the amount of the volumes of the operating space during operation and accordingly to determine the position of the piston by simple means.

It is claimed for the invention that this object is attained by means of a piston-type accumulator which has features (a) to (d) as indicated in Claim 1.

Consequently, the piston-type accumulator claimed for the invention permits contact-free indication through the wall of the accumulator housing of the position of the piston, so that simple and reliable monitoring of the operating state of the accumulator during operation is possible.

In that, as claimed for the invention, at least one, preferably two, Hall sensors are provided as magnetic field sensors which respond to changes in the field which result from piston movements, an electric signal is made available for indication of the piston position; this creates advantageous options for configuration of the position display, for example, in the form of a signal-controlled optical and/or acoustic display, optionally also in the form of a remote display.

In advantageous exemplary embodiments the piston is made of a non-magnetizable material and the magnet configuration has a plurality of permanent magnets which are mounted at a radial distance from the circumference of the piston in a row concentric with the longitudinal axis of the piston, with reciprocal polarity so that their polar axes extend in parallel with the longitudinal axis.

With the polar axes in such a position, introduction of the magnetic flux into the wall of the cylindrical tube consisting of a magnetizable material results in a field line pattern such that a high proportion of the field lines extends longitudinally. Piston movements in one or the other

axial direction consequently result in significant signal changes caused by the Hall effect as a result of approach to one or the other Hall sensor.

In one especially advantageous exemplary embodiment the permanent magnets are retained on the piston between ring elements of magnetizable material which adjoin the pole ends of the permanent magnets. These ring elements of magnetizable material may be configured so that parts of their circumferential areas are moved into the proximity of the interior wall of the cylindrical tube and form pole shoes for introduction of magnetic flux into the wall of the cylindrical tube.

The invention is described in detail in what follows with reference to an exemplary embodiment illustrated in the drawing, in which

- FIG. 1 presents a simplified diagram of a longitudinal section of an exemplary embodiment of the piston-type accumulator claimed for the invention;

- FIG. 2 a longitudinal section on a somewhat larger scale exclusively of the piston of the exemplary embodiment shown in FIG. 1; and

- FIG. 3 a top view on the same scale as that of FIG. 2 of one of the two ring elements positioned atop the piston of the exemplary embodiment and forming a pole shoe of the magnetic configuration on the piston side.

The accumulator housing of the exemplary embodiment shown in the drawing of the piston-type accumulator claimed for the invention has a cylindrical tube 1 of a magnetizable material such as a steel alloy. There is in the cylindrical tube 1 a piston 3 of a non-magnetizable material (special steel) or an aluminum alloy or the like. This tube may be moved back and forth in the axial

direction, which is represented by a longitudinal axis 5. The piston 3 acts as movable separating element between two operating spaces present in the cylindrical tube 1, in the exemplary embodiment a gas storage space 7 and a fluid space 9.

The cylindrical tube 1 is closed off on the end closing off the gas storage space 7 by a threaded cylinder cover 11. A gas channel 13 to which a gas valve or a charging fitting (neither of which is shown) may be connected extends through the cylindrical tube 1. Similarly, the cylindrical tube 1 is closed off on the end associated with the fluid space 9 by a threaded cover 15, which has a central fluid passage 17.

The piston 3 has a trough-like depression 19 which is concentric with the axis 5 and is open on the end of the piston facing the gas storage space 7 so that it increases the volume of the gas storage space 7. On the end of the side of the piston having the open end of the depression 19 the piston 3 has a circumferential section 21 which extends opposite an adjoining circumferential section 23 to the end of the piston facing the fluid space 9 and is of a smaller exterior diameter. The exterior diameter of this circumferential section 23 is adapted to the interior diameter of the cylindrical tube 1 so that it fits on the inside of the cylindrical tube 1 so as to be gas-tight. For this purpose the circumferential section 23 has circumferential annular grooves in which piston seals 25 and a piston guide strip 27 (all of a design customary in piston-type accumulators) are seated.

Ring elements 29 and 31, both of which are made of a magnetizable material, are present on the circumferential section 21 of reduced exterior diameter of the piston 3. A top view is presented in FIG. 3 of the ring element 31 shown in FIGs. 1 and 2 as being at the bottom. As is to be seen in FIG. 2, the upper side of the ring element 31 has a series of depressions 33 (not all of which are shown in FIG. 3) extending concentrically over the circumference of the ring element 31; these depressions 33 are in the form of circular depressions of small depth arranged at regular

angular distances over the entire circumference, depressions 33 being provided in the exemplary embodiment 22 illustrated. Each of the recesses formed by the depressions 33 serves as seating for a cylindrical permanent magnet element 35 the polar axes of which extend in parallel with the longitudinal axis 5 and the end polar surface of which adjoins the bottom of the depressions 33.

The ring element 29, shown in the illustrations to be above and configured to be a mirror image of ring element 31, also has corresponding depressions 33 which form the seat of the polar end surfaces of the permanent magnet elements 35. Consequently, the row of magnet elements is mounted between the ring elements 29 and 31. A threaded ring 37 which is screwed onto an exterior threading 39 on the adjacent end of the piston holds the ring elements 29 and 31 in contact with the magnet elements 35 and in contact with a sealing element 41, which is inserted between lower ring element 31 and a shoulder surface 43 which forms a planar surface on the transitional area between the circumferential sections 21 and 23 of the piston 3. The sealing element 41 secures the magnet and pole shoe configuration in the event of any impact of the piston 3 on the bottom of the piston housing (not shown in detail).

As is to be seen in FIGs. 1 and 2, the ring elements 29 and 31 have, in their circumferential area 35 adjoining the magnet elements, an exterior diameter which creates a radial spacing from the cylindrical tube 1 so that a free space is formed for receiving non-magnetizable guide and sealing elements 47 (see FIG. 2). In its circumferential area 49 more remote from the magnet elements 35 the exterior diameter of the ring elements 29 and 31 approximates the interior diameter of the cylindrical tube 1. In this configuration the ring elements 29 and 31 form pole shoes for introduction of the magnetic flux into the wall of the cylindrical tube 1 by way of the circumferential areas 49 approximating it.

As is to be seen in FIG. 1, two Hall sensors 51 are mounted on the exterior of the cylindrical tube 1; these sensors 51 respond to changes in the magnetic field which occur as the piston 3 moves along the path of its stroke in the cylindrical tube 1. As is indicated by the connecting cables 53

of the Hall sensors 51 designated as 53 in FIG. 1, these sensors 51 are mounted on the cylindrical tube 1 so as to be opposite in orientation, so that approach to the piston 3 in its upper end position and its lower end position, this corresponding to strengthening of the magnetic field in each instance with different polarity of the field lines on the respective Hall sensor 51, in each instance results in a positive increase in the Hall voltage signal. As is also to be seen in FIG. 1, the Hall sensors 51 are mounted at an axial distance from each other such that one Hall sensor 51 is within the area in which the magnet elements 35 are in one end position of the piston 3, while the other Hall sensor 51, having been displaced to the other end of the cylindrical tube 1, is within an area in which the magnet elements 35 of the piston 3 are in the other end position of the latter.

Of course, the Hall voltages generated by the Hall sensors 51 and identifying the position of the piston 3 may be processed by any suitable method in order to obtain indication of the position of the piston 3. Introduction of the magnetic flux of the magnet elements 35 into the wall of the cylindrical tube 1 by way of the ring elements 29 and 31 functioning as pole shoes yield significant signal values based on the Hall effect. It is to be seen, of course, that the excitation selected for the flux by way of the ring elements 29 and 31 functioning as pole shoes need be only great enough to obtain adequate signal values. In order to prevent occurrences of stronger, possibly disruptive, magnetic force effects resulting from the magnetic flux between the magnet configuration on the piston 3 and the cylindrical tube 1, reduction of excitation to values sufficient for display purposes may be provided, for example, by providing a small air gap between the circumferential areas 49 and the cylindrical tube 1 or by introducing between circumferential areas 49 and cylindrical tube 1 a thin wall of piston guide means of a non-magnetizable material.

In a modified embodiment of the piston-type piston-type accumulator claimed for the invention the possibility also exists of omitting the depressions 33; the two ring elements 29 and 31 are then configured to be level on their sides facing each other, the magnet elements 35, configured

to be cylindrical, then extending axially between the two planar surfaces of the ring elements 29 and 31 at radial distances from each other. The respective configuration is essentially reproduced as shown by the top view in FIG. 3 if the upper side of the cylindrical magnet elements 35 be assumed in place of the depressions 33.

Only one Hall sensor 51 for monitoring position or determining the piston 3 may also be provided in place of the two Hall sensors shown in FIG. 1. Depending on the function assigned, more than two Hall sensors 51 may also monitor the respective displaced position of the piston 3 and forward it to appropriate evaluating electronics. Consequently, the solution claimed for the invention also makes possible monitoring of the end position of the piston 3 by the two Hall sensors 51 as illustrated in FIG. 1.